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13. ABSTRACT *(Maximum 200 words)*

This grant provided support for the collection, analysis, and publication of results from the Subduction Accelerated Research Initiative. The hypothesis of this contribution to the Subduction experiment was that downward fluxes at fronts may provide a major source of surface water to the interior of the ocean. This hypothesis was addressed using a trio of surveys of the Azores Front in the North Atlantic done in May 1991 and March 1992. These surveys were made using a towed vehicle (SeaSoar) equipped with a conductivity-temperature-depth profiler and a shipboard acoustic Doppler current profiler.

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The scientific objectives of this work were: (1) to identify subducted layers from maps of temperature, salinity, potential density, and potential vorticity, (2) to isolate the geostrophic velocity using absolute velocity and density data, and (3) to diagnose the vertical velocity at a front. Rudnick and Luyten (1996) reported the results of addressing objective (1). Both potential density and potential vorticity indicated that dense water from the north side of the front was sliding down beneath the surface outcrop. Objectives (2-3) were addressed in Rudnick (1996). The geostrophic velocity was found in a two-step procedure consisting of objective analyses to reflect the observed length scales, and dynamical adjustments to the density and velocity fields to be statically stable and in geostrophic balance. Vertical velocity was diagnosed using a version of the quasigeostrophic omega equation. There was a tendency for the cooler northern water to be downwelled and the warmer southern water to be upwelled. The implied heat flux exceeded 10 W m^{-2} near 100 m depth, thus stratifying the upper ocean. The inferred circulation cells may be an important mechanism of subduction in the upper ocean.

This grant also allowed me to finish analysis and publication of data from the Frontal Air-Sea Interaction Experiment (FASINEX). The heat budget in the North Atlantic subtropical frontal zone was examined using moored current meter data (Rudnick and Weller 1993a). The time-dependent Ekman spiral was investigated at high frequencies using data from both FASINEX and the Long-Term Upper Ocean Study (LOTUS) (Rudnick and Weller 1993b). The ocean's response to surface heating may also be depicted as a spiral (Lee and Rudnick 1996). Finally buoy-measured air-sea fluxes were compared to climatologies and numerical products from the European Centre for Medium-Range Weather Forecasting (ECMWF) and the Fleet Numerical Oceanography Center (FNOC) (Weller et al. 1995).

References

Refereed Journals

Lee, C. M. and D. L. Rudnick, 1996: The upper ocean response to surface heating. *J. Phys. Oceanogr.* **26,** 466-480.

Rudnick, D. L., 1996: Intensive surveys of the Azores Front, 2, Inferring the geostrophic and vertical velocity fields. *J. Geophys. Res.* in press.

Rudnick, D. L. and J. R. Luyten, 1996: Intensive surveys of the Azores Front, 1, Tracers and dynamics. *J. Geophys. Res.* **101,** 923-939.

Rudnick, D. L. and R. A. Weller, 1993a: The heat budget in the North Atlantic subtropical frontal zone. *J. Geophys. Res.* **98,** 6883-6893.

Rudnick, D. L. and R. A. Weller, 1993b: Observations of superinertial and near-inertial wind-driven flow. *J. Phys. Oceanogr.* **23,** 2351-2359.

Weller, R. A., D. L. Rudnick and N. J. Brink, 1995: Meteorological variability and air-sea fluxes at a closely spaced array of surface moorings. *J. Geophys. Res.* **100,** 4867-4883.

Abstracts, Talks and Reports

Kadko, D. and D. Rudnick (1991) Evidence of subduction within the Azores Front. Eos Trans. AGU, 72(51) (suppl.): 79.

Lee, C. M. and D. L. Rudnick (1994) Upper ocean response to surface heating. Eos Trans. AGU, 75(3) (suppl.): 33.

Rudnick, D. L. (1995) Subduction at the Azores Front. Contributed abstract at the International Association for the Physical Sciences of the Oceans XXI General Assembly.

Rudnick, D. L. and F. Bahr (1992) Cruise report for Subduction 2. SeaSoar News, 3, 5-7.

Rudnick, D. L. and J. R. Luyten (1991) An intensive survey of the Azores Front. Eos Trans. AGU, 72(51) (suppl.): 79.